NOVEL CARBON FILMS FOR NEXT-GENERATION ROTATING EQUIPMENT APPLICATIONS

BENEFITS

The availability of superlow-friction carbon coatings would lead to the following benefits.

- Energy savings through reduced frictional losses in rotating equipment.
- Environmental benefits through reduced fluid leakage and fugitive emissions from production plants.
- Financial benefits through improved equipment reliability and reduced maintenance costs.

The benefits will be crosscutting and will impact many IOF industries.

APPLICATIONS

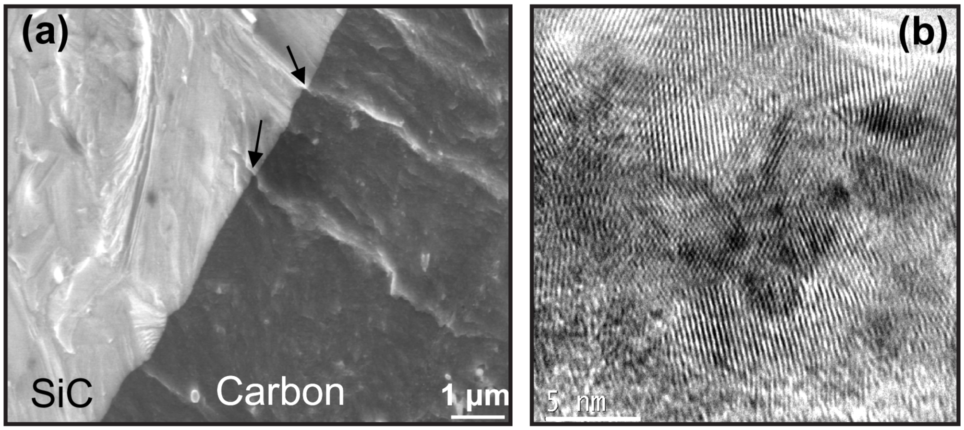
Applications will occur in various IOF industries for seals and other rotating equipment. The project will develop two novel carbon technologies to achieve extended wear life and higher energy savings in rotating equipment applications including mechanical seals, sliding bearings, and shafts. The results will be applicable to many of the IOF industries:

- **Agriculture**,
- **Aluminum**,
- **Chemical**,
- **Forest Products**,
- **Glass**,
- **Metalcasting**,
- **Mining**,
- **Petroleum**, and
- **Steel**.

NEAR FRICTIONLESS CARBON FILMS CAN LEAD TO IMPROVED ROTATING EQUIPMENT EFFICIENCY AND LIFE

This project aims to combine the unique qualities of two novel carbon technologies to achieve extended wear life and higher energy savings in rotating-equipment applications, including mechanical seals, sliding bearings, and shafts. Materials to be explored in this project are a superlow-friction carbon film [Near Frictionless Carbon (NFC)] and a carbon conversion film with structure and properties ranging from graphite to diamond [Carbide Derived Carbon (CDC)].

The focus of the R&D is the development of adherent, low-friction, wear-resistant coatings for SiC and other metal carbide ceramics for rotating seal applications. Activities will include treating SiC components to produce CDC surface layers, characterizing the coatings and substrates, and evaluating of coated components tested in the laboratory and in industry. NFC coatings will be applied to both untreated and CDC-treated components.



(a) SEM micrograph of a fracture surface showing CDC on a SiC substrate. Note that the fracture features are not deflected at the interface, indicating that mechanical properties do not change sharply between the SiC and CDC. (b) TEM micrograph of the nanocrystalline diamond region in CDC near the interface.

Project Description

Goal: The goal of the project is to develop superlow friction carbon films with structures and properties ranging from graphite to diamond for seal and bearing applications.

Issues: The combined technology promises to eliminate many of the problems now experienced by SiC-based seals. SiC is a very hard material; however, it is very brittle and wears out rapidly during high-speed rotating contacts in face seals.

The key hurdle to be overcome in this project is the development of a low-friction carbon film that can be applied to a silicon carbide face seal at low cost and that can provide low-friction and high-seal-efficiency service in industrial environments. The technical feasibility for the production of both types of carbon films has been established in earlier work at University of Illinois at Chicago and Argonne National Laboratory. Remaining tasks concern the optimization of the process parameters and properties of the coatings in situations where they contact one another.

Approach: The objective of the project will be to develop a protective carbon coating that minimizes friction losses, surface wear, and leakage of fluid associated with carbide ceramic seals, bearings, and other rotating contact applications in service. The project will consider CDC carbon films, NFC carbon coatings, and combinations of the two in order to achieve this objective. The coatings will be characterized and evaluated in terms of structural, mechanical, and tribological characteristics; performance in a simulated fluid seal tester will serve as the ultimate test for the coatings.

Commercial metal carbide wear components for rotating machinery will be supplied by the commercial partner, Chicago-Allis Manufacturing Corporation, for treatment in the program. Chicago-Allis will also perform final testing on prototype coated components produced in the project and will coordinate commercialization of the optimized coated seals.

Potential payoff: The results of the R&D will be applicable to various IOF industries for seals and other rotating equipment. The development of the two novel carbon technologies can lead to extended wear life and higher energy savings in rotating equipment applications such as mechanical seals, sliding bearings, and shafts. Higher energy efficiency of shaft seals in chemical processing pumps alone could lead to energy savings of more than 10×10^{12} Btu/year.

Progress and Milestones

- SiC components will be treated to produce CDC surface layers, and NFC coatings will be applied to both untreated and CDC-treated components.
- Coatings will be characterized.
- Tribological testing will be performed and results analyzed.
- Post-test characterization of coatings will be performed, and results will be compared to pre-test values.
- Coated parts will be produced and evaluated in industrial settings.
- Components with optimal coatings will be supplied to industrial partners for evaluation.

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PRIMARY

University of Illinois at Chicago
Chicago, IL

PROJECT PARTNERS

Argonne National Laboratory
Argonne, IL

Chicago-Allis Manufacturing Corporation
Chicago, IL

Drexel University
Philadelphia, PA

Charles A. Sorrell
Office of Industrial Technologies
Phone: (202) 586-1514
Fax: (202) 586-7114
Charles.Sorrell@ee.doe.gov

Mike Soboroff
Office of Industrial Technologies
Phone: (202) 586-4936
Fax: (202) 586-7114
Mike.Soboroff@ee.doe.gov

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Office of Industrial Technologies
Energy Efficiency
And Renewable Energy
U.S. Department of Energy
Washington, DC 20585
http://www.oit.doe.gov

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